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THE BOTANICAL GAZETTE

EDITORS:

JOHN M. COULTER, Lake Forest University, Lake Forest, Ill.
CHARLES R. BARNES, University of Wisconsin, Madison, Wis.
J. C. ARTHUR, Purdue University, Lafayette, Ind.

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In the January number will appear:

Undescribed plants from Guatemala. XII, by JOHN DONNELL SMITH, *Baltimore, Md.*

Archinema, protonema and metanema, by CONWAY MACMILLAN, *University of Minnesota, Minneapolis.*

On the color descriptions of flowers, by J. H. PILLSBURY, *Springfield, Mass.*

Mutualistic symbiosis of algæ and bacteria with Cycas revoluta, by ALBERT SCHNEIDER, *University of Illinois, Champaign.*

RUSSELL ON BACTERIAL FLORA OF ATLANTIC.

BOTANICAL GAZETTE

DECEMBER, 1893.

The bacterial flora of the Atlantic ocean in the vicinity of Woods Holl, Mass.

A contribution to the morphology and physiology of marine bacteria.

H. L. RUSSELL.

WITH PLATE XXXVI.

(Concluded from p. 417.)

Description of new forms.

While some of the forms that have been isolated at Woods Holl have been identified with those found in Mediterranean waters, the predominant species have in most cases specific differences that separate them from the European species. A careful search in the systematic works of Eisenberg, Frankland, Lustig, and others that describe mainly the water forms failed to give any evidence that the forms here dealt with had been previously recorded. This is not at all surprising when we take into consideration the fact that the systematic part of bacteriology has heretofore concerned itself mainly with the fresh water types and that little or no attention has been given the marine bacterial flora.

I have, therefore, described the predominating species that have been isolated and studied during the past season in order that we may have a basis for comparison with European marine forms.

The difficulties of a satisfactory classification of bacterial species have not as yet been entirely overcome, but the present tendency to introduce physiological and ecological characters in the description of new forms is virtually a necessity. The correlation of form and function in the living organism is so close that both factors must be considered in

any accurate and thorough description that will enable a later student to positively identify the species.

The bacterial flora of any particular habitat may be considered in two ways—qualitatively or quantitatively. Often there is a wide diversity as to the number of different forms that are present in any particular location, but as a rule the majority of individual organisms belong within the limits of comparatively few species. This is more especially true with reference to a region in which the adventive or introduced forms are comparatively few, and with the great bulk of oceanic waters these conditions prevail. Where they receive the drainage of large river systems or are subject to sewage contamination of large cities, the number of species as well as the number of individual germs is usually increased, but these conditions do not obtain with reference to the locality investigated this season.

The location of Woods Holl is so favorable with respect to the possibility of the introduction of adventive forms that it seems highly probable that the conditions here are quite normal and may fairly represent the condition of marine bacterial life in general.

While the water and mud masses of this region possess bacterial life in considerable abundance, no great variety of species is to be noted. The four or five forms that will be described in detail comprise by far the larger proportion of living germs that are to be found. In numerous instances, the cultures contained not more than two or three species, and very rarely did any single culture show more than four or five different forms.

This peculiarity is quite noteworthy, as the number of predominating species of any particular habitat is rarely so small as in this case.

Bacillus limicola, sp. nov.—This species is the most characteristic indigenous inhabitant of the ocean bottom in the Atlantic near Woods Holl. Almost every test that was made from the mud revealed the presence of this bacillus.

In regard to its morphological characters, it is a bacillus, but it has a variability of form and size that is quite remarkable. If a cover glass preparation be made from a rapidly developing agar culture, such wide diversity of forms present themselves, that one can scarcely avoid the conclusion that the culture has become contaminated, even though he may

be satisfied as to the purity of its origin. There are bunches of short oval forms, almost spherical, that closely resemble large micrococci (fig. 1, *B*, *a*), others of an elongated normal bacillus type, often united in short filaments (fig. 1, *B*, *c*), while still others are curved after the manner of a spirillum.

The variability of form is also accompanied by a wide range in size, not only among the different growth forms but among those of the same morphological structure. Besides what seems to be the typical, elongated bacillus, there are often seen individual cells, having one end pointed, or lance-shaped (fig. 1, *B*, *b*). These cells are usually united in pairs, the larger ends being in contact and present a strong resemblance to the lanceolated forms found in Bac. pneumoniæ. The range in size of the bacillus type of this germ varies within the limits of 0.7–1.8μ in width, while the length is sometimes no more than 1μ and from that to 5μ. The short spheroidal cells are as a rule somewhat wider than the bacillus type, and have a more refringent aspect that closely recalls the appearance of arthrospores of some species, but the cell union of these forms would hardly be conceivable with true spores.

Then, too, the fact that old non-sporogenous cultures, having these refringent cells, were killed at the comparatively low temperature of 55°C. is against the view that they are genuine spore stages of this bacillus.

Whether the wide variation in form and size is due to the pleomorphic nature of the species or to involution changes is a question. These appearances are to be noted in cultures 24^{hrs} old and in hanging drop preparations the unstained bacteria have the ordinary optical properties of active protoplasm, but when subjected to staining agents like methylene blue or carbol-fuchsin, they stain so irregularly as to lead one to believe that a degeneration of the protoplasm has already begun. Cover-glass preparations stained by Gram's method are not decolorized.

When the germ was first isolated at Woods Holl, spores were often observed in agar cultures kept at ordinary summer heat, but in later cultivations on both salt and fresh water media, I have been unable to demonstrate them either at room temperature or blood heat. This peculiarity is somewhat remarkable, yet the observance of this phenomenon with other bacterial forms like anthrax when cultivated on

artificial media for considerable time shows that this condition is not exceptional. It is another instance that goes to show how intimate the relation is between the organism and its environment; how that by modification of exterior surroundings, such a deep seated phenomenon as that of reproduction may be profoundly affected.

The chromogenic function of this bacillus is best seen when grown on an agar medium. On this substratum, it presents a fairly copious growth, smooth and shining. At first the color is but slightly developed, but as the culture increases in age, it passes from an ochreous yellow to a deep rich orange. There is considerable variation in the production of the pigment depending upon the temperature at which the culture is grown. Cultures kept at blood heat remain very pale and do not develop, even in old age, the rich orange tint that is seen in growths kept at the temperature of the room.

In gelatin the growth characters are as follows: In tube cultures 24 hours old, there is a slight pit observable at surface point of inoculation caused by the liquefaction of the gelatin. This spreads superficially, and also gradually deepens until there is a broad liquefied funnel formed in the gelatin that slowly widens until the sides of the tube are reached. Usually there persists for several days at the surface, an air pit in the medium, caused by the evaporation of liquefied material. The consistency of this liquid mass is thick but not viscous. The fluid gelatin is filled with a slightly flocculent precipitate that remains in suspension, while a considerable amount of amorphous yellowish growth material is deposited on bottom. No membrane is formed on the surface of the fluid.

The appearance of colonies in gelatin plates is not especially characteristic. The germs quickly liquefy the medium in a regular circular form. Macroscopically, the edge of the colony is translucent while opaque patches of zoogloœa cover the center. These are usually of a dull, grey color, but are sometimes tinged with a faint reddish lustre when observed in reflected light. Under the lens, the edge of the colony is granular, the extreme periphery being the densest. Short irregular filaments radiate from the extreme edge into the surrounding gelatin.

On agar, the germ develops quite rapidly although not very luxuriantly. The culture appears on the second day as a

smooth, shining colony that spreads out in a thin layer over surface of medium.

The young cultures are often tinged with yellow, but this gradually deepens with age until it reaches a rich orange brown.

On potato, no growth could be obtained, while in milk, the casein was entirely peptonized although but a slight amount of acid was produced. The milk serum remains turbid. Under anaerobic culture conditions, no growth could be noted.

Bacillus pelagicus, sp. nov.—One of the most common and widely distributed of the marine bacteria that have been observed in this locality is a small, short bacillus that has been named B. pelagicus.

This species was found abundantly in both water and mud, and in almost every culture that was made. The mud layers were filled with it, both in a vegetative and a spore condition, so that it is evident that its presence on the sea bottom is not to be accounted for by simple deposition of the spores from the water masses above. It is found abundantly in the vicinity of the shore, as well as in the samples that were taken by the *Grampus* 100 miles from land.

Morphologically, it is a slender bacillus, usually quite short ($0.4\mu \times 1.5$–2.5μ), but a number of segments may be united into filaments of various lengths. In vigorous cultures, the shorter forms have a very lively, tumbling movement. Small, narrow spores are easily formed on different media at ordinary temperatures. This bacillus takes aniline stains easily. When Gram's solution is used, the bacilli show a spotted appearance, the granules retaining the stain while the remainder of the cell is decolorized.

In cultures it grows fairly well, although not luxuriantly. In gelatin plate cultures growth is not rapid, but the food-medium is gradually liquefied, the grayish white growth masses settling to the bottom of the colony. Under the microscope, the colony presents the usual granular appearance, the edge of it being sharply defined. In gelatin tubes, the appearance of the cultures is more characteristic. It spreads superficially more rapidly than in vertical direction, forming a shallow cup filled with homogeneously granular, turbid, liquefied gelatin that is covered with a copious white film on surface.

The predilection for oxygen is further shown when cultures are made under anaerobic conditions. In deep gelatin tubes

and in cultures prepared according to Buchner's pyrogallic method, it does not develop.

The liquefaction of the gelatin in ordinary tube cultures progresses slowly until the side of the tube is reached and then continues steadily to the bottom in horizontal layers. In old cultures, the film on the surface often has a reddish hue. The appearance along submerged portions of the needle track indicates only a scant growth.

Streak cultures on agar show a thin hazy film becoming more opaque in lower part of tube where condensation water collects. On agar plate cultures, considerable variation is to be noted. Sometimes the colonies are small and opaque, then again they are often spread out in a thin film as in tubes. The colonies on agar are more or less viscid, and adhere easily to the needle when touched.

On potato, this bacillus is a chromogene and grows more luxuriantly on this than any other medium. In thirty-six hours, at room temperature, the culture growth is apparent where it appears as a glistening yellowish drop around inoculation puncture.

This rapidly spreads until the whole surface of potato is often covered with a deep orange-yellow growth that changes later in old cultures to a brick red.

Milk is modified profoundly, the casein being coagulated by the production of acids. This coagulated material is soon peptonized, the serum remaining more or less cloudy.

Bacillus litorosus, sp. nov.—This form was found in both water and mud layers in not inconsiderable numbers, although not nearly so common as B. pelagicus.

Morphologically, it belongs to the larger type of bacteria, being a slender, typical bacillus form ($1\mu \times 4\text{–}7\mu$). It is usually found as an isolated individual or closely united in short chains of two or four segments. The protoplasm of the cells is usually homogeneous. This form is motile and is characterized by a slow, stately movement of a serpentine nature.

In ordinary gelatin media, it forms quite a characteristic culture. Two or three days after inoculation, liquefaction of gelatin is to be noted at the surface and along needle track as well. The peptonizing of this substance takes place more rapidly at surface, so a broad funnel shaped sac is formed as a result of two or three days' growth. There is usually

a sharply defined air pit at the surface, the base of which is covered with grayish masses of zoogloœa. In the lower part of the liquefied needle track, spirally twisted strands are to be noted. A thick membrane is finally formed on surface from bits of flocculent zoogloœa that adhere in masses which easily rupture upon the slightest movement. In old cultures, the bottom of the liquefied gelatin is covered with flocculent growth masses and the culture is not especially characteristic.

On agar, this bacillus grows rapidly, forming a thick dull white colony with a sharply defined border. Under the lens, the edge of the colony is seen to be formed of numerous parallel filamentous bands, that are looped at the edge so there are no freely projecting filaments radiating into the surrounding medium.

In agar tubes, these well defined grayish patches become confluent and more luxuriant in the lower part of the tube. At room temperature, the germ thrives better than at blood heat. In deep stick gelatin or agar cultures as in bouillon tubes prepared according to Buchner's pyrogallic acid method, a marked growth is to be noted, showing the facultative nature of the germ.

On potato there is a well defined compact white growth that is soft in texture and easily detached. When inoculated into milk, this bacillus sets up a very rapid change coagulating the casein and finally peptonizing it. The serum of the milk is at first filled with a cloudy precipitate that is formed from the masses of zoogloea but these are finally deposited on the coagulated casein.

Bacillus maritimus, sp. nov.—Bacillus maritimus is found quite plentifully distributed in the mud layers. It is a sporogenous bacillus of good size (dimensions $1.50\mu \times 3.5$–6μ) with round ends, but the cells are usually quite closely united into filaments of varying length. The protoplasm has often a granular appearance so characteristic of marine bacterial forms. The spores are small, scarcely exceeding one-half the width of the cell ($0.7\mu \times 1.5\mu$). These are readily formed in forty-eight hours at the room temperature.

On artificial media this germ grows luxuriantly. It is seemingly indifferent to the salt content of the substratum upon which it develops. In gelatin, two days growth is marked as follows: a very shallow pit spreads out over surface, the bottom of which is covered with a grayish growth that

has the peculiar luster so characteristic of the freshly broken surface of limestone. From the base of this shallow depression fine filaments radiate for a short distance into the gelatin. Growth along needle track is barely visible, thus showing the aerobic nature of this germ. In three days, this superficial growth spreads slowly to the sides of the tube and the gelatin is slowly peptonized in horizontal layers, the liquefied material being filled with cloudy masses. An imperfect film that is easily ruptured is often to be observed on surface of culture.

On agar, growth is copious but not especially characteristic. The surface of the medium is covered with a dense white covering smooth in character.

On potato it also thrives luxuriantly as a thick grayish white coating covering nearly whole surface of potato. Surface of growth is dull and mealy in texture.

Conclusions.

It may be well to summarize briefly the results that have been reached in the foregoing pages in the following general conclusions:

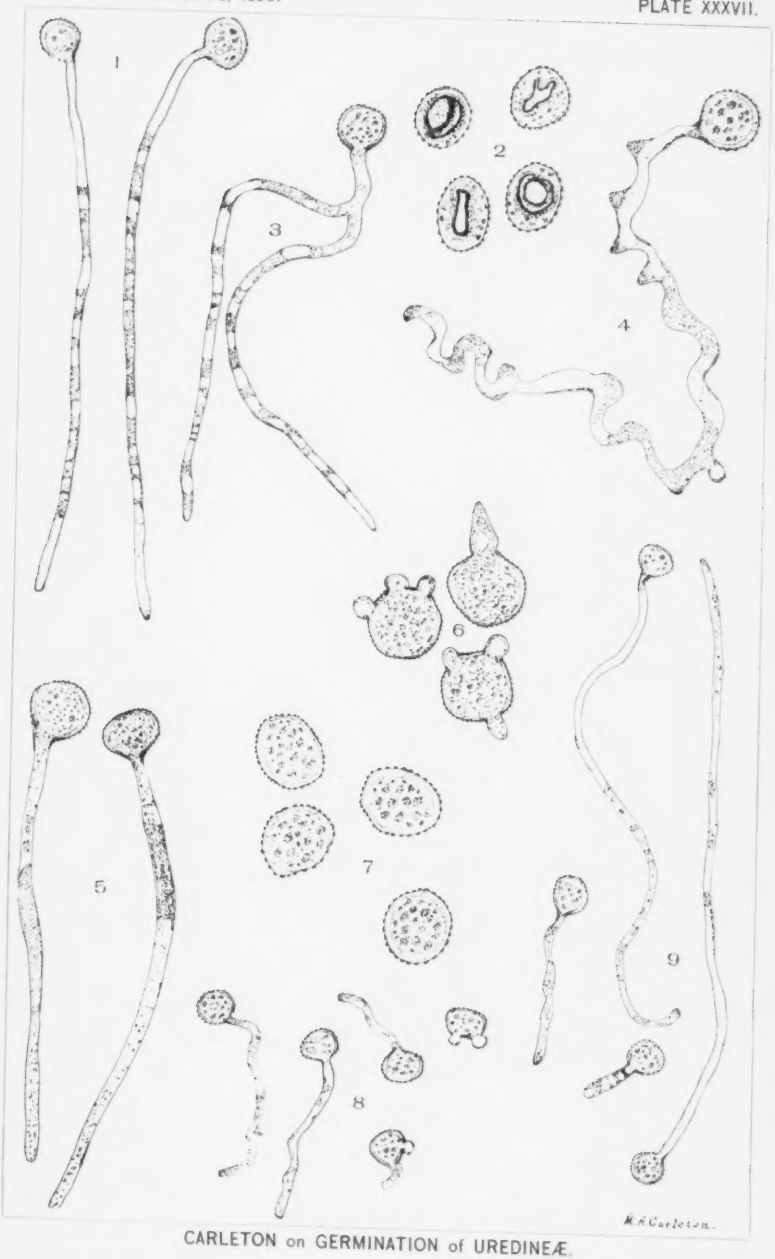
1. Bacteria are present in the oceanic waters, both of the high seas and in litoral regions, although they are not so abundant as they are in fresh water masses.

2. While the bacterial flora of the sea bottom in the region investigated this year is not near so great, from a numerical standpoint, as that in the neighborhood of Naples, yet the accuracy of the general conclusions drawn from the Mediterranean work in regard to the slime bacteria is strengthened by the present season's work.

Bacteria exist in the mud of the ocean bottom in large numbers, and their presence there is not due merely to the effect of gravity but to the growth and reproduction of indigenous slime species. Forms that are prevalent in the water masses above are also found in the mud layers in a vegetating as well as in a latent stage of development.

3. Disregarding the influence of introduced forms from the land, which is in this case very slight, the indigenous marine flora of both water and sea floor is largely comprised within the limits of relatively few species.

These may often be distributed over more than localized areas, and in some instances come to be cosmopolitan in their



CARLETON on GERMINATION of UREDINEÆ.

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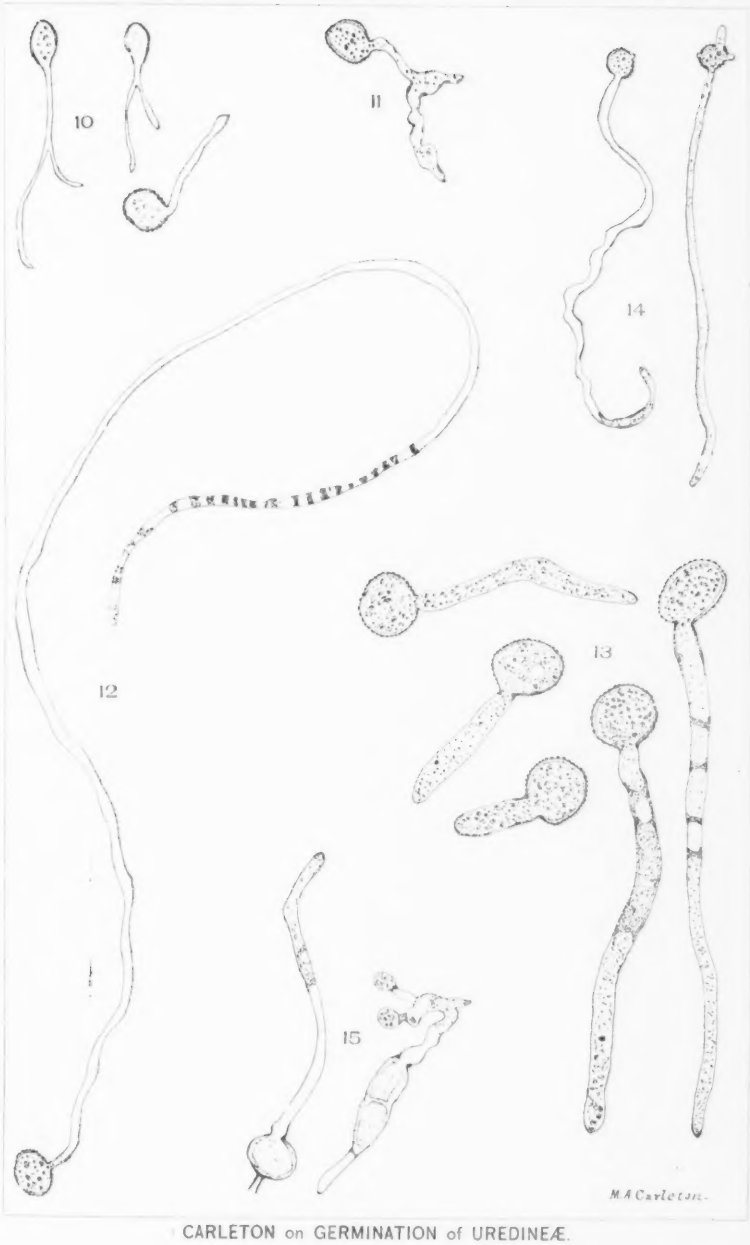

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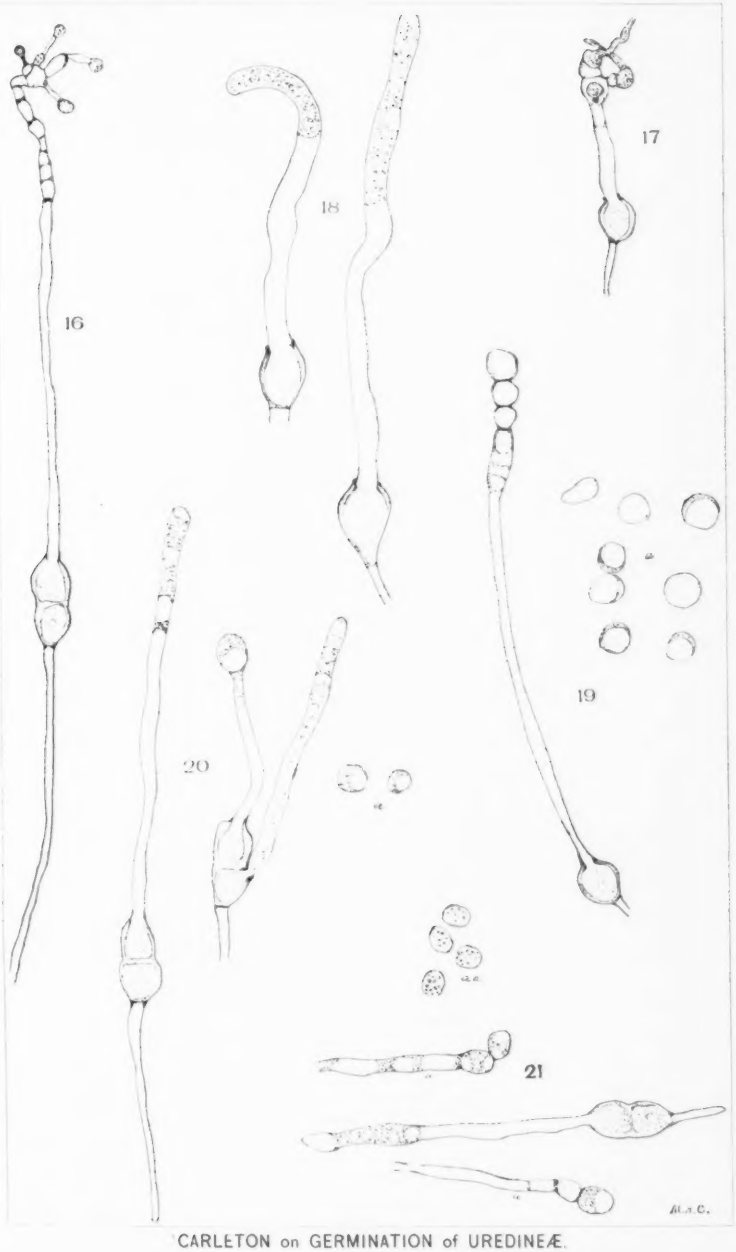


CARLETON on GERMINATION of UREDINEÆ.

range. Not only is their geographical distribution often extensive but the vertical range of the various forms exceeds that of the majority of the higher forms of life.

4. While no pathogenic property was noted in any of the forms isolated, other physiological characters, as the formation of soluble enzymes and the ability to reduce nitrate salts, were conspicuous characteristics of the more prevalent forms.

University of Wisconsin.

EXPLANATION OF PLATE XXXVI.—Figures of bacteria in cultures drawn with a Zeiss microscope, tube length 160^{mm}, no. 6 compensating ocular and $\frac{1}{12}$ homogeneous oil immersion.

Fig. 1. *A. Bacillus limicola*, gelatin culture 5 days old.
Fig. 1. *B. a*, Short type of cells from agar culture; *b*, lanceolate type from old agar culture; *c*, normal bacillus type from agar culture, 3 days old.
Fig. 2. *A. Bacillus pelagicus*, culture in gelatin.
Fig. 2. *B.* Spore bearing bacilli from gelatin culture, two weeks old.
Fig. 3. *A. Bacillus maritimus*, gelatin culture, 2 days old.
Fig. 3. *B.* Single cells from potato culture, 2 days old.
Fig. 4. *A. Bacillus litorosus*, 3 days growth in gelatin.
Fig. 4. *B.* Cells from young gelatin culture.

Studies in the biology of the Uredineæ. I.

Notes on germination.

M. A. CARLETON.

WITH PLATES XXXVII–XXXIX.

Within the last eighteen months I have made about four hundred cultures of uredineal spores, in various media, at various seasons, in order (1) to determine as many facts as possible concerning their biology on the one hand, and on the other hand, by observing the various effects of different chemicals upon their germination, (2) to obtain a working basis for the preparation of fungicides for the prevention of the attacks of certain economic species. A great part of the work, particularly that of most economic importance, has already been reported.[1] What I shall present here, are some results and suggestions of a more technical nature.

Nearly all the cultures made were of the ordinary drop culture style, prepared by depending a drop of the employed medium, in which the spores were immersed, from the lower surface of a cover-glass placed over an ordinary glass cell

[1] Kansas Agric. Exp. Sta. Bull. *38*. Mar. 1893.

made by glueing a glass ring to a slide. The bottom of the cell had previously been moistened with water, so that a miniature damp chamber was thus formed. In order to more certainly guard against drying, the further precaution was observed, of placing the cultures themselves in a large damp chamber. Occasionally, simple watch glass cultures were prepared, but these were seldom found to be useful, on account of their great liability to contamination.

1. Effects of different chemicals upon germination.

In carrying on the experiments in this line, one or more check cultures in water were always included in every series of cultures prepared at any one time. The results of the cultures in the various solutions were compared with those of the water cultures, and in every series where germination failed, both in water and in the other solutions, the whole experiment was discarded, of course. The uredospores of grain rusts were used in most of the experiments, particularly the uredo of *Puccinia coronata* Corda, since that species was the most abundant for the longest period in 1892, when the majority of these experiments were performed. In the following tables I give the names of those solutions only which show the most striking results, either favorable or unfavorable. The tables represent only a small proportion of the cultures actually made. The numbers in the column "strength" give the number of parts, by weight, of the commercially prepared chemicals to 10,000 parts of distilled water, in which they were dissolved. The first table shows results obtained with uredospores of *Puccinia Rubigo-vera* (DC.) Wint.:

Time (hrs.)	Medium.	Strength.	Results.
21	Ferrous sulphate,	10	Not very good.
21	Potassium sulphide,	10	Fairly good.
21	Copper sulphate,	10	Failure.
18	Hydrogen peroxide, (0.3 per cent. sol.),	10	Better than in water.
18	Potassium sulphide,	10	Not very good.
18	Copper sulphate,	10	Three spores germinated.
18	Copper nitrate,	10	Five spores germinated.
18	Potassium chromate,	10	Failure.
48	Atropine,	100	Failure.
48	Aloin,	100	Failure.
48	Aloin,	10	Not very good.
48	Cocaine,	100	Failure.
29	Broth of wheat leaves,		Success—long germ tubes.
29	Neutralized urine,		Only a few spores germinate—long germ tubes.
29	Non-neutralized urine,		Very few spores germinated.
29	Milk,		Success.
44	Wheat leaf broth,		Success.
44	Beef broth,		Success.

The next table shows results obtained with uredospores of *Puccinia graminis* Pers.

Time (hrs.)	Medium.	Strength.	Results.
7	Copper sulphate,	10	Poor, but not an entire failure.
7	Hydrogen peroxide (0. 3 per cent. sol.),	10	Good.
7	Potassium sulphide,	10	Good.
42	Hydrogen peroxide (0. 3 per cent. sol.),	10	Failure.
48	Aloin,	10	Success.
48	Chloral hydrate,	10	Failure.
48	Atropine,	10	Failure.
67	Potassium bi-chromate,	1	Not many spores germinated.
67	Salt,	10	Success,
67	Cinnamon decoction,	71.4	Very few spores germinated.
48	Camphor (commercial solution),	100	Success.
48	Tannic acid,	10	Failure: swells the germ pores.
48	Salicylic acid,	100	Failure: decolorizes the spores.
48	Morphine,	100	Failure.
48	Morphine,	10	Failure.
48	Chloroform,	10	Failure.

In the following table, including the most extensive experiments of all, are shown the results obtained with uredospores of *Puccinia coronata* Corda.

Time. (hrs.)	Medium.	Strength.	Results.
22	Potassium chromate.	10	Partial failure; a few spores germinated.
22	Copper sulphate.	10	A few spores germinated.
24	Copper nitrate.	10	Very few spores germinated.
22	Copper acetate.	100	Total failure; decolorizes, then discolorizes the spores.
22	Lead acetate.	10	Total failure.
22	Ferric chloride.	10	Failure; colors spores green.
22	Potassium permanganate.	10	Success.
23	Corrosive sublimate.	1	Failure.
23	Potassium bi-chromate.	10	Failure; contracts and shrivels spores.
24	Hydrogen peroxide (0.3 per cent. sol.).	10	Success; very free germination.
24	Potassium sulphide.	10	Success; better than in water.
27	Ammonium sulpho-cyanide.	10	Success; very free germination.
27	Chrome alum.	10	Success; very free germination.
27	Potassium chromate.	10	Three spores germinated.
24	Copper chloride	10	Failure; decolorizes spores.
24	Potassium sulphide.	10	Success.
24	Potassium sulphide.	100	Failure.
24	Lead acetate.	10	Not many spores germinated; germ tubes stunted.
24	Copper acetate.	10	Failure.
47	Sodium arsenite.	10	Success.
47	Potassium chromate.	10	A few spores germinated.
47	Copper nitrate.	10	A few spores germinated.
48	Ammonium carbonate.	10	Success; very free germination.
48	Ferric chloride.	10	Very few spores germinated.
52	Sodium thio-sulphate.	10	Success.
52	Potassium per-manganate.	10	Success; not very free germination, however.
16	Lead acetate.	10	Very few spores germinated.
16	Ammonium carbonate.	100	Success; but germination not very free.
16	Magnesium chloride.	10	Success.
16	Ammonium sulpho-cyanide	10	Success.
16	Chrome alum.	10	Fairly well.
16	Sodium thio-sulphate.	100	Success.
27	Magnesium chloride.	10	A few spores germinated.
25	Potassium chromate.	10	Failure.
25	Sodium thio-sulphate.	100	Success; but germination not very free.
25	Nitric acid.	68	Failure.
25	Nitric acid.	6.8	Success; very free germination.
25	Corrosive sublimate.	1	Failure; decolorizes spores.
25	Potassium sulphide.	10	Success.
25	Acetic acid.	10.8	Failure.
25	Acetic acid.	0.54	Success.
18	Sulphuric acid.	10	Failure; decolorizes spores.
18	Potassium cyanide.	1	Success; very free germination.
52	Potassium cyanide.	10	Failure.

Time. (hrs.)	Medium.	Strength.	Results.
19	Potassium bi-chromate.	1	Fairly well.
24	Potassium sulphocyanide.	10	Five spores germinated.
26	Copper acetate.	1	A few spores germinated.
26	Copper sulphate.	1	Very few spores germinated.
26	Corrosive sublimate.	0.1	A few spores germinated.
26	Potassium bi-chromate.	1	Success, but not very free: swells out germ pores.
26	Copper nitrate.	1	Failure.
26	Lead acetate.	1	Six spores germinated.
21	Copper sulphate.	1	Success.
21	Potassium chromate.	10	Success.

Germinations of other species were not sufficiently extensive to justify tabulation. *Æcidium Fraxini* Schw. failed to germinate in copper sulphate (1:1,000) in twenty-six hours, and in potassium bi-chromate (1:1,000) same time, but germinated successfully in the latter solution with a strength of 1:100,000, producing peculiar short bulb-like germ tubes, for illustration of which, see pl. XXXVII, fig. 6. Quite a number of summer spore-forms, including various aecidia and uredines, germinated more or less freely in weak solutions (five to ten per cent.) of sugar and honey. In only one instance have I been able to grow the spermatia. The spermatia of *Uredo Cæoma-nitens* Schwein. budded sparingly, on May 31, 1893, after twenty-four hours in a dilute solution of honey, but would not germinate in water. This is in confirmation of the results obtained by Cornu[2] and Plowright.[3]

A careful comparison of the results above given, justifies certain conclusions of interest and importance. (1) Compounds containing mercury, copper, iron, lead and chromium (where these elements are in sufficient proportions), and strong acids, are *inimical* to the growth of Uredineæ. (2) Compounds containing oxygen, sodium, potassium, magnesium, sulphur and probably carbon and ammonium, in great proportions, are *favorable* to the growth of Uredineæ. (3) Alkaloids are injurious to the growth of Uredineæ. The compound radical cyanogen, might properly come under group (1), for, although the sulpho-cyanides of ammonium and potassium are not unfavorable, such fact may be explained by

[2] Bull. de la Soc. de Bot. de France XXIII (1876). 120–121.
[3] British Uredineæ and Ustilagineæ, 14–16.

the presence of the favorable element sulphur, not present in potassium cyanide. Again, while bi-chromate of potassium is extremely injurious, chrome alum is rather favorable, which may be explained by the fact of there being such a small proportion of chromium in the latter compound, compared with its amount in the former. The effect of the element nitrogen is hardly determined by these experiments, but the majority of the facts seem to point to its being injurious, since its presence in alkaloids makes the only difference, as far as mere composition is concerned, between these compounds, which are injurious, and the carbohydrates which are favorable; and since it is the greater constituent, by weight, in the unfavorable radical, cyanogen. The correctness of this idea would tend to overthrow the opinion, often expressed, that an excess of nitrogenous compounds in soils is favorable to the growth of rust. Another conclusion to be derived from the results of these experiments, is (4) that potassium sulphide and sodium hyposulphite, common fungicides, are likely to be entirely useless for the prevention of rusts, since the spores grow readily in solutions of these compounds, even with the latter in a solution of 1:100.

Dr. E. Wüthrich,[4] the only one, as far as I know, who has experimented in this same line, has had results very similar to my own, in so far as he has reported them. In his experiments with uredospores of *Puccinia graminis* Pers., germination took place in a solution of potassium nitrate of fifty per cent. strength. I did not use this salt at all, but it will be noted that it contains the favorable element, potassium, that I have already mentioned. On the other hand, he has not reported the employment of potassium bi-chromate, one of the salts having the most injurious effect upon germination in my own experiments. But where we have used the same compounds, the results have been practically the same.

2. Vitality and vigor of the summer spore-forms.

Uredospores and æcidiospores have much greater powers of endurance than have usually been ascribed to them. Wüthrich, in his article above cited, makes the following statement with respect to the resistance of uredospores of *Puccinia gra-*

[4] Ueber die Einwirkung von Metallsalzen und Säuren auf die Keimfähigkeit der Sporen einiger der verbreitesten parasitischen Pilze unserer Kulturpflanzen. Zeits. f. Pflanzenkrankheiten II (1892). 84–86.

minis to the action of various solutions in their germination, compared with spores of other fungi, with which he also experimented: "The spores of various fungi show unlike powers of resistance against solutions of metal-salts and acids. The conidia of *Peronospora viticola* prove to be the most susceptible of the forms investigated. Then, following these, in the order of decreasing sensibility, are the conidia of *Phytophthora infestans*, æcidiospores of *Puccinia graminis*, conidia of *Claviceps purpurea*, spores of *Ustilago Carbo*, and uredospores of *Puccinia graminis*."[5] According to this statement, uredospores have, comparatively, great powers of resistance to various solutions, and there is the further fact that æcidiospores are much less resistant than uredospores, both of which facts are further established by my experiments, so far as I have gone.

They are also similarly resistant to extremes of cold. It was already well known that the mycelium of *Puccinia Rubigo-vera* can pass the winter without injury, in the tissues of its host.[6] Experiments at this station have further proved that even the *uredospores* are preserved during the winter months, and may be taken from the field in *any month* of the year and easily germinated.[7]

A plant of *Carex* (*vulpinoidea?*) bearing both uredospores and teleutospores of *Puccinia Caricis* (Schum.) Rebent. was transplanted to the green-house from out doors in December, 1892, and uredospores, taken from this plant in January following, readily germinated, producing germ tubes of rather peculiar form—wide, and often branching (pl. XXXVIII, fig. 11). Germination would probably have taken place at the time of transplanting, but was not attempted. *Æcidium tuberculatum* Ell. & Kell. is still producing æcidiospores on *Callirrhoe involucrata*, out doors, here at Manhattan, at the time of this writing (October 15th), and Mr. E. Bartholomew, of Rooks co., Kan., tells me that he has seen in December æcidiospores on specimens of this host growing close by a large snowdrift. In the spring, æcidiospores of this species begin forming about the first day of April. Æcidiospores of *Æcidium Pentstemonis* Schwein., and uredospores of *Uromy-*

[5] l. c. translated from p. 93.

[6] See Sorauer, Handbuch der Pflanzenkrankheiten, ed. 2. II. 216; and Bolley, Bull. Agric. Exp. Sta. Ind. *26*, 13 and 19.

[7] See Bull. Kan. Agr. Exp. Sta. *38*, 11, for full discussion of this matter.

ces Zygadeni Pk. and *Puccinia Hieracei* (Schum.) Mart. begin forming also about April 1st.

It is not always necessary that the summer spore-forms should be fresh in order to germinate readily, although fresh spores usually germinate best. Spores of *Æcidium pustulatum* Curt. and *Uredo Cæoma-nitens* Schwein. collected at Lawrence, Kan., May 19, 1892, and placed in drop cultures at this station the next day, germinated freely in 31 hours, producing vigorous germ tubes. I have often germinated uredospores, after they had lain in the collecting can one or even two days. Prof. B. T. Galloway,[8] several years ago called attention to the great scarcity of ash rust, *Æcidium Fraxini* Schwein., in 1888, and to the fact that various attempts, by the Division of Vegetable Pathology, to germinate it in different media, were only partially successful at that time. At the same time he suggested the question whether the rust might not germinate more readily in seasons of great abundance. As bearing upon this question, it may be of interest to say that in the summer of 1892 the rust was extremely abundant here, particularly on young trees, attacking the twigs as well as the leaves and sometimes entirely destroying large portions of the branches for a distance of two feet or more. At the same time, the spores were easily and repeatedly germinated in ordinary watch glass cultures, although it had been difficult for me to germinate them at other times. I think I have observed the same fact with respect to other species.

As to the length and rapidity of growth of germ tubes, there is great variation among the different species. Those of the uredospores of *Puccinia Rubigo-vera* represent about the average length, so far as my observations have extended. Those of *Puccinia Hieracei* are a little longer than the average. (See pl. XXXVIII, fig. 14.) Those of *Puccinia graminis*, and of various rusts on grasses, are much longer. The one figured in pl. XXXVIII, fig. 12, has a length of 1.075^{mm}, and is but little, if any, longer than the average for that particular culture, of seventy-two hours. Uredospores of *Puccinia Sorghi* Schwein. sometimes show no indication of germination during the first day, but finally, at the end of forty-eight hours, produce germ tubes of very fair length. Other species seem to produce their entire growth in twenty-four

[8] Journ. Mycol. v (1889). 95.

hours. Germination in the same species will vary greatly, according to the conditions. Fig. 8, pl. XXXVII, shows the progress that various spores have made at the end of four hours. On January 25, 1892, uredospores of *Puccinia Rubigo-vera*, taken from outdoor plants, germinated in *two hours* in warm water, producing germ tubes 50μ long. In this case germination could actually be seen going on. The germ pores began swelling almost immediately on being placed in the water.

3. A new method of producing sporidiola.

In the course of my experiments with the germination of teleutospores, I have observed a new process in the formation of sporidiola[9] not hitherto mentioned so far as I know.[10]

In the ordinary process it is well known that the sporidiola are stalked, or attached to pedicels of peculiar shapes—usually very much narrowed at the point of attachment. These are well illustrated in pl. XXXVIII, fig. 15 and pl. XXXIX, fig. 16. The pedicels may arise from various points for some distance along the promycelium, or they may be almost in clusters, originating from points rather close together. The process that I shall describe is very different, and is as follows: At first the promycelium presents the ordinary appearance, but presently there is an evident disposition in the terminal portion to separate into well-marked divisions. The protoplasm concentrates in these divisions; constrictions form between them; the divisions, at first much longer in the direction of the promycelium, become shorter and wider, then rounded, and finally, separate from the remaining portion of the promycelium, as free spherical bodies, by the ordinary process of acrogenous abjunction. A half dozen or more may be produced in succession from the same promycelium. Of course those nearest the end are the oldest, and may be in the process of separation while those farthest back are just beginning to form.

We have in this process a production of *catenulate* sporidiola, in contradistinction to the *pedicelled* sporidiola hitherto observed. I have observed this process in three species, *Puccinia Grindeliæ* Pk., *P. variolans* Hark. (so-called) on *Aplo-*

[9] I use this term, in preference to "sporidia," in order to avoid confusion with the sporidia of ascomycetes and other groups. It is suggested by Saccardo, in "Rathschläge für die Phytographen insbesondere die Kryptogamisten;" Hedwigia XXX. (1891). 56–59, and used by De Toni in Sacc. Syll. VII. 528.

[10] Lagerheim *possibly* refers to it (Jour. Mycol. VII. 46–47), but he observed only LEPTO-UREDINEÆ, in which I no not find this process.

pappus spinulosus, and in the mesospores of *P. Sporoboli* Arth. This process of germination may prove to be of importance in classification, and help to clear up the existing confusion regarding some of our western so-called LEPTO-PUCCINIÆ on composites. I am not yet prepared, nor have I the space in this article, to make any statements, on this basis, concerning the systematic position of such species.

In two other cases, those of *Puccinia Malvastri* Pk. and the *Puccinia* of *Lygodesmia juncea*, the indications were that catenulate sporidiola would be formed, but germination ceased before reaching that stage. The germination of *Puccinia Sporoboli* was the most remarkable. In this case, not a *single two-celled* spore germinated while the *mesospores* germinated profusely, uniformly producing catenulate sporidiola.

All these species, except *Puccinia Sporoboli*, were collected in October, 1892, and germinated after being kept in paper pockets till April, 1893. It may be said that this fact may have had something to do with the peculiar germination of these species, and possibly it did, but *Puccinia Phragmitis* (Schum.) Körn. and *Puccinia Redfieldiæ* Tracy were collected at the same time, and after passing through the same treatment, germinated in April, also, but with the production of the ordinary pedicelled sporidiola; besides, *Puccinia Sporoboli* was taken from fresh out-door material.

I have constantly had much aid from Prof. A. S. Hitchcock, in the course of my investigations, particularly in the selection and preparation of the various solutions used in germination.

Kansas Experiment Station, Manhattan.

EXPLANATION OF PLATES XXXVII—XXXIX.

Fig. 1. Germination of uredospores of *Puccinia coronata* Corda, in ammonium carbonate (1:1000), after 48 hrs. × 247.

Fig. 2. Condition of the same, in potassium bi-chromate (1:1000), after 23 hrs. × 333. Spores much contracted and shrivelled.

Fig. 3. Germination of uredospores of *Puccinia Rubigo-vera* (DC.) Wint. in sodium chloride (1:1000), after 21 hrs. × 247.

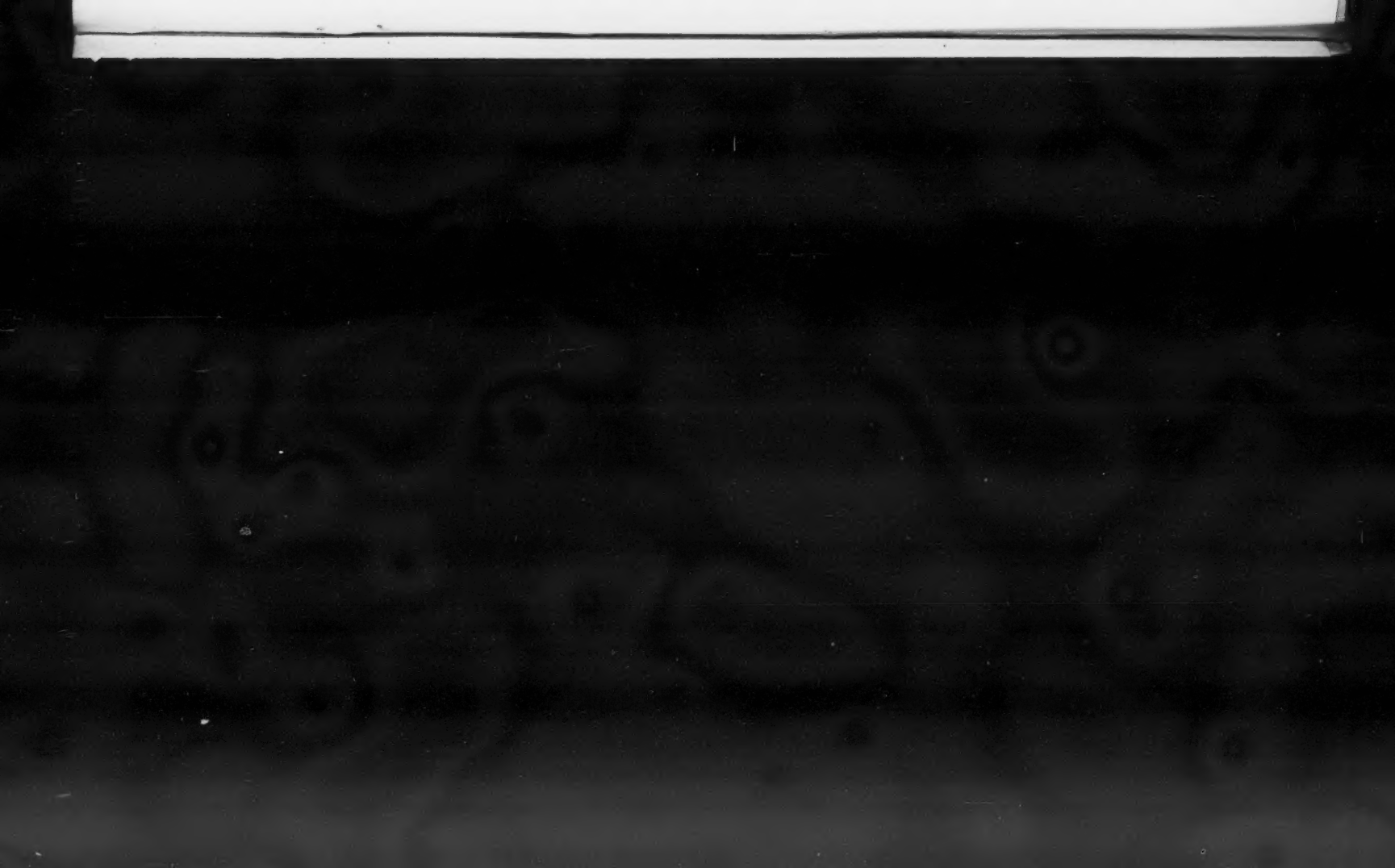
Fig. 4. Germination of uredospores of *Puccinia coronata*, in sodium thiosulphate (1:1000), after 52 hrs. × 333. Germination vigorous.

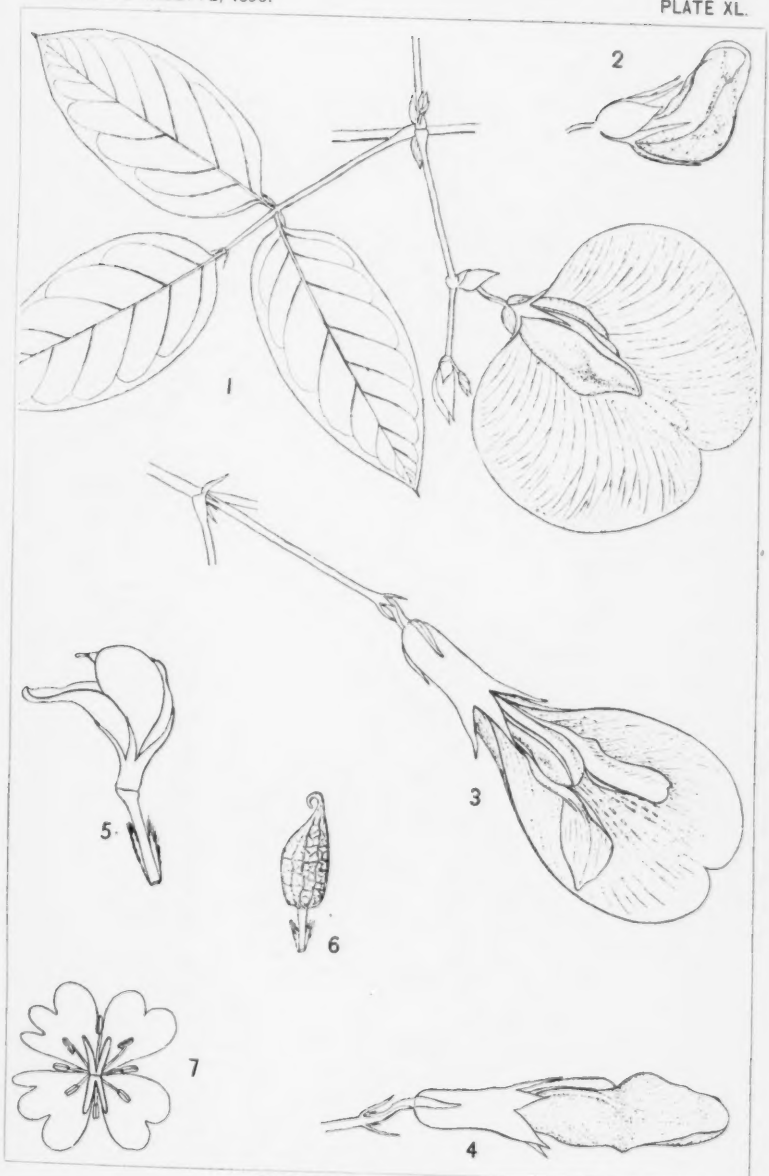
Fig. 5. Germination of *Æcidium Fraxini* Schwein., in watch-glass water culture, after 3 days, June 15, 1892. × 333.

Fig. 6. Germination of the same, in potassium bi-chromate (1:100,000), after 28 hrs. × 333.

Fig. 7. Condition of uredospores of *Puccinia coronata* in lead acetate (1:1000), after 22 hrs. × 333.

Fig. 8. Germination of uredospores of *Puccinia Rubigo-vera*, in water, after 4 hrs. × 200. Shows the various stages in germination.





FOERSTE on LEGUMINOSÆ.

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Fig. 9. Germination of the same, in water, after 44 hrs. Jan. 21, 1893. × 200. Spores taken from volunteer wheat, out doors.

Fig. 10. Spores taken from dead leaves of volunteer wheat, out doors, Feb. 25, 1893. Seem to have germinated on the wheat, and further growth checked by the cold. × 247.

Fig. 11. Germination of uredospores of *Puccinia Caricis* (Schum.). Rebent. in neutralized urine, after 50 hrs. Jan. 1893, × 333. Spores from green-house plant, transplanted from out doors Dec. 1892.

Fig. 12. Germination of uredospores of *Puccinia graminis* Pers. in water, after 72 hrs. Germ tube measures 1.075mm. × 247.

Fig. 13. Germination of *Uredo Cæoma-nitens* Schwein. in water, after 31 hrs. Put in drop culture next day after collection, May 19, 1892. × 333.

Fig. 14. Germination of uredospores of *Puccinia Hieracei* (Schum.) Mart. in water, after 24 hrs. Apr. 30, 1892. × 167.

Fig. 15. Germination of teleutospores of *Puccinia Redfieldiæ* Tracy, in water, after 46 hrs April 29, 1893, collected Oct. 1892. × 247. One mesospore is shown to be germinating.

Fig. 16. Germination of teleutospores of *Puccinia Phragmitis* (Schum.) Körn. in water, after 4 days, April 1893, collected Oct. 1892. × 247.

Fig. 17. Germination of teleutospores of *Uromyces Polygoni* (Pers.) Fuckel. in water, after 46 hrs. April 29, 1893, collected Oct. 1892. × 247.

Fig. 18. Germination of teleutospores of *Uromyces Sporoboli* Ell. & Ev. in water, after 48 hrs. Apr. 17, 1893. × 333.

Fig 19. Germination of teleutospores of *Puccinia Sporoboli* Arth. in water, after 48 hrs. Apr. 17, 1893. *a*, sporidiola. × 247. Only the mesospores germinated, producing catenulate sporidiola.

Fig. 20. Germination of teleutospores of *Puccinia Grindeliæ* Pk. in water, after 20 hrs Apr. 24, 1893, collected Oct. 1892. Producing catenulate sporidiola. *a*. sporidiola. × 247.

Fig. 21. Germination of teleutospores of *Puccinia variolans* Hark.? of *Aplopappus spinulosus*, in water, after 19 hrs., producing catenulate sporidiola. *a*, terminal portions of promycelia, isolated, showing sporidiola in the process of abstricting. *aa*, sporidiola free. × 247.

Botanical notes from Bainbridge, Georgia. I.

AUGUST F. FOERSTE.

WITH PLATE XL.

Rootstocks penetrating the ground vertically.

Every one knows how roots penetrate the ground. The minute terminal rootlets find their way along crevices between the particles forming the earth, and the increasing bulk of the root pushes these particles aside. It is different with a rootstock. Its existence on germination begins near the surface of the ground and if it penetrates the ground vertically it must penetrate it backwards.

Where plants grow in marshy soil, as in the case of *Symplocarpus foetidus*, this is readily understood, but when the ground is more compact it is quite another matter. It must

especially be observed that the older the plant, the deeper the base of the rootstock will penetrate, and the broader it will become as a rule and hence the greater will be the direct resistance to be overcome. In many cases a more or less definite portion of the base of the rootstock dies every year. In that event the remaining portion of the rootstock must pass also through the space left by the decayed part, before it can sink its base to a still lower level.

It is difficult to understand how the broad base of a thick rootstock such as that of *Agave Virginica* L., for instance, or other still more striking instances, penetrate the hard ground. One thing I have noticed is that plants of this description usually have good stout vertical roots from year to year, and that these begin to wrinkle transversely towards the close of the season. Having a very good grip on the ground by means of the minor rootlets, the tension they exert on the rootstocks by their contraction in length must be enormous, but so must also be the resistance of the earth below the rootstocks. The only plausible explanation therefore seems to be, that the base of the rootstocks are able to force a passage slowly, little by little, when the ground is much softened by rains. This is a subject needing more investigation than has hitherto been given to it.

In this connection it was interesting to observe the habits of one of the palmetto palms, *Sabal Adansonii* Guerus. Here the rootstock is not drawn into the soil backwards but quite the reverse process takes place. In fact the initial narrow end of the rootstock is here directed upwards, and the later growth is formed along the rootstock deeper in the soil, so that a considerable part of the rootstock is pointed directly downwards, earthward, increasing in size in the same direction. At the lower thickened end, the tip of the rootstock is however bent abruptly to one side and then up until the tip itself points upwards. Strong roots are attached to the old rootstock and strong roots are also sent out at the just described strong bend below. It is evident that this curved portion straightens itself out at intervals, the roots drawing the successively newer and straightened portions down into the soil. In this way the base of the curved portion of the rootstock behind the tip is sometimes found at a level of considerably more than a foot beneath the level of the soil, from which level the rootstock must have started.

In the oldest plants the straightening out below the tip does not keep pace with the development of the axis about the tip, or its increase in length, so that the tip beyond this curvature is greatly thickened, producing a sort of tuberous rootstock. The general effect of this thickened end is that of the bowl of a short Dutch pipe, of which the older, longer end, tapering towards the initial extremity near the surface of the ground, represents part of the pipe-stem. The rootstocks of this palmetto may therefore be said to grow indirectly downwards into the soil, and they are not hauled down backwards as a whole, as is the case with so many other vertical rootstocks.

Notes on Leguminosae.

1. Changes in color of flowers.—The genus *Tephrosia* permits several interesting though not striking remarks on the changes of colors in flowers. *T. spicata* T. & G. has pure white flowers when fresh, turning purple on fading. *T. ambigua* Curtis has white flowers, the veins and the midrib of the keel, except toward the margins, being colored almost russet red. The flowers very soon became tinged light pink or rose, and on fading also turn purple. *T. hispidula* Pursh. is described as having purple flowers. It is evident that the chemical substances giving rise to the purple color are present in all these flowers, but they are differentiated at different times. In the first species this does not take place until the time of fading. In the second it has taken place in the veins when the flower opens, and soon begins in a mild way over the entire surface of the petals. In the last species the differentiation of this purple coloring matter has been completed before the flower blossoms.

It may perhaps also be inferred that this purple coloring matter (stable only under more vigorous conditions of the cells forming the petals) is due to the breaking up of previously existing chemical compounds, owing to a sort of process to disintegration or decay, since the change towards a purple color in the first two species takes place either at the time of fading, or at least is, in the second species, strongly accentuated at that time. The inflorescence consists of peduncled racemes, which are terminal. By the development of branches from the axils of the last leaf, a sympodial growth ensues, which in the case of *T. ambigua* may give rise to a number of

seemingly axillary peduncled racemes, which in reality, however, all terminate as many axes of growth.

2. *Flowers with the lower side turned up.* — Such an one is *Clitoria Mariana* L. The peduncle of the one- to three-flowered raceme is axillary and bears two minute opposite bracts at its base. In typical cases the lower flower pedicel on this raceme is subtended by three bracts of which the lateral ones represent stipules and the central one which is tripartite represents the subtending leaf. At the base of the pedicel are two opposite bracts equal in size to those last mentioned, so that five bracts cluster around its base. At the base of the calyx two similar opposite bracts occur, which structurally decussate with the lower pair, though owing to a twist of the pedicel through ninety degrees the last two pairs of bracts lie in the same plane.

This twist can easily be followed. Without it, the keel of the flower should structurally face laterally; following the general habit of Leguminosæ it should face downward, as a matter of fact however, and largely owing to the twist of the pedicel, it faces upwards and *the flower is thus turned with the lower side up.* The upper flower pedicel has, at its base, one bract to represent the subtending leaf, or a tripartite bract when solitary. Two more bracts, opposite to each other, occur at the base of this pedicel, two more occur as usual at the base of the calyx, and the intermediate pedicel is again twisted. *The tip of the axis of the raceme is aborted* and remains as a minute tip at one side of the base of the last pedicel.

Owing to the long tubular calyx and the broadly spreading habit of the vexillum the flower has a narrowly obovate appearance. The wings equal five-sixths the length of the vexillum, and the last two-fifths of the length is free from the keel, and is large and spreading. The keel is one-third the length of the vexillum. It is composed of two petals which are held together by a ridge near the inner margin of one petal with a deep groove along its outside and a corresponding infolded portion at the inner margin of the other petal, a little mucilaginous substance helping to keep them in place. The wings are free except near the middle of the expanded terminal portion of the side of the keel, where they are strongly pasted to the keel by a mucilaginous substance. The whole thus forms a case for the stamens and pistil, which is closed below (in a struc-

tural sense), and in front, but which above, is open for most of its extent, this portion of the case being held together only by the walls of the tubular calyx. Near the tip, however, the outer sides of the petals of the keel are strongly infolded, overlap, and are pasted together by a mucilaginous substance leaving only the acute tip free, as a passage for the terminal end of the style.

The stamens are diadelphous, the upper stamens being structurally free, though pasted to the inner sides of the lower monadelphous portion formed by the other nine stamens. The base of this tenth stamen is free for one millimeter to permit the escape of the honey formed by the horseshoe shaped gland at the base of the stamens within the tube.

The upper third of the stamen is also entirely free. The tenth stamen is held in position not only by the mucilage, but also by the fact that the sides of the slit tube formed by the remaining stamens are in a state of tension and press upon the tenth stamen, laterally springing back when loosened. The lower side of the flattened style is smooth, the upper side is hairy, as is also the stigma, especially along its upper margin. When visited by bees only the upper portion of the style appears above the tip of the keel, its upper hairy surface pushing out the pollen.

Centrosema Virginiana Benth. is so closely related as to have been described as a *Clitoria* by Willdenow. Its general habits are the same. Two bracts are found at the base of the peduncle and from the axils of these may arise one or two additional peduncles, also with two basal opposite bracts on each. All three peduncles have different times of flowering. At the base of the pedicels are three bracts representing the subtending leaf with its stipules, or an obovate bract with three teeth along the quadrangular apex, representing the same, or a single simple ovate bract, in which all three elements are probably united. The tripartite bracts subtend the lower, the rest the upper pedicels. The *two bracts* which in Clitoria occur at the base of the pedicels, *in Centrosema are united into a single large ovate bract* directly over the bract at the base of the pedicel. At the base of the calyx are two large ovate bracts a little shorter than the teeth of the calyx, and if the next lower bract were divided into two as it should be morphologically, then the bracts at the base of the calyx would decussate with the latter.

The pedicels are again twisted, so that the keel is turned upwards and the vexillum downwards. The calyx tube is 5^{mm} long, and its teeth extend 11^{mm} beyond the tube. The vexillum is large and orbicular. The wings almost equal the keel in size, the latter being about one-half to four-sevenths the length of the standard. The wings are appressed to the sides of the keel, following its curvature, and are pasted to the latter by a mucilaginous substance. The two petals of the keel are grown together along their (structurally) lower, inner sides, and, excepting at the base, also along their upper sides, which do not overlap, but meet along their edges. Perhaps the microscope might show that they were here held together along their thin edge by mucilage, but under an ordinary lens they seem to have actually grown together, though so weakly as to permit of separation with any moderately pointed instrument. At the apex of the keel the petals however remain free for a length of 4 or 5^{mm}, and through this slit both the upper part of the style and the stamens are protruded when the flower is visited by bees. This being the case there is no need of hairs along the flattened style to serve as a pollen brush and these are absent. The stigma however is hairy, the largest hairs being along the upper margin.

The upper stamen is *free* and on dissecting the flower is always found distant from the remaining stamens. The latter, of which there are nine, have their filaments united so as to form a tube, remaining structurally open along the top. Excepting at the very base however, and near the apex, the sides of this slit are pressed together, being under tension, so that there is formed a practically closed tube. The slit can be opened by means of any moderately pointed instrument. Perhaps the sides are a little grown together or held together by some mucilaginous substance. The terminal bud on the axis of the flowering raceme seems never to develop though the evidence is not so good as in *Clitoria*. In both *Clitoria* and *Centrosema* therefore, the pedicels are twisted and the flowers turned with the lower side up, so that the visiting insects, chiefly bees, and certain butterflies, receive the pollen on their backs, instead of on their sides and the lower part of their body, as is the case when ordinary *Leguminosæ* are visited.

There is still another papilionaceous plant which arrives at the same results, but in a different way. This is *Stylosanthes elatior*. It has "flowers of two kinds; one kind perfect

but sterile; the other destitute of calyx, corolla, and stamens, and fertile." The fertile flowers consist therefore solely of the legume; a leaflet with two adnate stipules subtends the same, and a pair of bracts is found at the base. The legume has a lateral position. On examining the perfect flowers, these and their legume are also seen to have a lateral position, so that it is impossible to say whether the fertile flowers always were destitute of other floral envelops and organs or not.

The lateral position of the legume is also the proper position for a pair of leaves belonging to the ovary, *directly* succeeding the bracts. The fertile flowers are the lower ones of the short spike. The sterile ones occupy the higher places.

The corolla is inserted at the summit of the constricted portion of the tube. This tube is erect. The standard is strongly reflexed so as to occupy a horizontal position. The keel rises above its plane, and arches forward over the standard. Any insect visiting this flower will therefore receive the pollen on its upper side.

The wings are attached to the keel by two moderately curved hooks; of these, the posterior one is situated at the base of the expanded portion, and is directed backwards, clasping over the inner edge of the free margins of the petals of the keel; the other is attached just above to the inner side of the wings, and is directed forwards, hooking into a corresponding deep depression at the base of the expanded portion of the keel. The petals of the keel are grown together below; above they are free, except the portion just behind the apex, where the *two inner sides* are applied to each other along a narrow margin, and are pasted together, face to face, or are moderately grown together. From the opening left at the apex of the keel, the tip of the barren style is usually exserted. When visited by insects the anthers are also pushed out, and the pollen is left on their heads. How from this place it reaches the recurved style of the fertile flowers below, except by dropping off, is a mystery. Perhaps the long, bristle like hairs on the subtending leaves and bracts serve as brushes. But even then it may be remarked that at least the earlier legumes seem already fertilized.

3. Inflorescences.—In the most complex case the peduncles of *Tephrosia* bear clusters of flowers, subtended by a bract. The next, a lateral pair of bracts, bear each a flower pedicel, without bracts. Immediately above the first bract mentioned

is another bract, in whose axil is a flower, without bracts; the bract belonging to this set, which should be found just in front of the peduncle behind the total inflorescence, is aborted. Next follow two lateral bracts above the first pair, each containing a flower, but in different stages of development. The terminal bud of the flowering axis must be either one of these two buds or be obsolete. The median plane of the flowers is vertical.

In the most complex case, the peduncles of *Lespedeza repens* T. & G., bear three or four alternating bracts, the successive ones more or less on opposite sides of the peduncle. Each of the bracts subtends an axis whose tip is aborted, but at whose base are a pair of lateral bracts, each subtending a flower. Consistent with this the apex of the peduncle is likewise aborted. Each flower pedicel bears a little below the calyx two bracts, and the median plane of the flower is vertical.

In *Rhynchosia tomentosa* T. & G., the inflorescences consist of short racemes in the axils of the upper leaves or tripartite bracts representing the leaves, or they are terminal. Whether the apex of these various racemes is aborted or not is unknown. The pedicels are subtended by bracts, but do not bear any themselves, and the median plane of the flowers is vertical. The ordinary plants bear leaves made up of these leaflets, but in the variety *monophylla* there is only one leaflet, though this shows its compound character by a joint near the upper end of the petiole, bearing the usual two minute scales.

Cassia obtusifolia L. has axillary racemes, of which the apex is aborted, and the members are confined to two opposite bracts near the base, subtending flowering pedicels. The latter, at their base, show each a small bract towards the front, the corresponding bract towards the rear against the stem being aborted, though a trace may sometimes be found in the form of hairy, horizontal lines. The median plane of the flower is vertical. A superposed bud occurs in the axils of many of the leaves, otherwise bearing the flowering axis.

Cassia Chamæcrista L. has axillary racemes, which are adnate, for a short distance above the axils, to the stem. The different flowering pedicels are subtended by bracts, and a little below the calyx are two bracts which, however, are distant from each other.

The above descriptions may suffice to show that the struc-

ture of the inflorescence of the *Leguminosæ* is quite variable. The inflorescences may be axillary, terminal, or pseudo-axillary only, owing to sympodial growth. The peduncles may or may not have a pair of opposite bracts at their base. The pedicels may have two pairs (of which one is then near the calyx), or one pair, or no pair of bracts at all, or two bracts may be grown together so as to form only one. The flowers may be in a lateral or in a vertical plane. The tip not infrequently can be proved to be aborted, which agrees with the general rule that *inflorescences composed of very irregular flowers usually do not develop flowers terminating the main axes*, and when such terminal flowers are developed contrary to the rule, these are not infrequently *regular* in form.

The reason why this should be so can of course be readily understood. In the process of forming irregular flowers out of regular ones, the bees and other insects visited chiefly the lateral ones which already were in a position to invite approach only from one direction. The upper terminal erect ones were then neglected and gradually became aborted.

4. Casting off of tips of branches.—Since the appearance of the later article on this subject a large *Mimosa* tree was noticed to have shed all the tips of its leaf branches late in May. The casting off of the tips in leguminous trees is quite normal. Indeed, it would be interesting to learn if there be *any* trees of that order which do form terminal scaly buds. Considering the frequency with which ligneous plants of this order shed their terminal leafy buds it may well be questioned whether the abortion of the terminal bud of the inflorescences of this family be not in large measure due to a general habit, instead of the special one following the above rule, according to which certain plants can be said to have no use for regular flowers, and terminal buds are only too apt to produce these. In this connection it may be of interest to refer to the case of *Apios tuberosa* Moench, described by the writer some years ago, in which the inflorescence, a compound panicle, first sheds the tip of the panicle with the attached racemes, and then sheds the upper flowers of all the remaining racemes, leaving the scars thus produced for extrafloral honey glands.

EXPLANATION OF PLATE XL.

Fig. 1. *Centrosema Virginiana*, Benth. Flower with the lower side turned up as in nature. Fig. 2. Same; side view of the bracts, sepals, wing, and keel. Fig. 3. *Clitoria Mariana* L. Flower with the lower side turned up as in nature.

Fig. 4. Same; side view of subtending bract-like leaf with its sepals, lower and upper bracts, calyx, wing, and a glimpse of the keel. Fig. 5. *Stylosanthes elatior* Swartz. Perfect, but infertile flower, furnishing only the pollen, a side view. Fig. 6. Female flower, consisting only of an ovary; the two bracts shown below. Fig. 7. *Œnothera linearis* Michx. with aberrant forms of petals. Bristol, Florida.

BRIEFER ARTICLES.

Bibliography of American botany.—The following circular has recently been sent to botanists and we desire to aid in giving it the widest publicity. See also editorial comment, p. 467.

"One item recommended by the Committee on Bibliography of the Madison Botanical Congress is an author catalogue of current works on American botany. To secure this Dr. N. L. Britton, editor of the *Bulletin of the Torrey Botanical Club*, kindly offered to change the monthly 'Index to literature relating to American botany' to the form recommended.

"Dr. Britton has experimented with details of form and typography and also, as planned, has experimented in reprinting the titles on regular index cards. He estimates that these cards will number nearly 1000 per year and that if the number of subscribers is sufficient, the series for 1894 can be supplied for five dollars.

"The cards will be of extra heavy linen ledger paper, accurately cut and the titles will be exact reprints of the matter that appears each month in the *Bulletin*, which will enable subscribers to keep the entire series in a single alphabet and to incorporate it with other indexes if they wish.

"This is the first step toward accomplishing the plans recommended by the Committee, and it is hoped that it will meet the approval and support of American botanists.

"Dr. Britton has asked the undersigned to take charge of subscriptions and the monthly distribution of the cards. It is important that we know very soon how many copies will be wanted. If you want it, kindly say so at once. If you can not subscribe now and think you may later, we need to know it. In any case please reply on enclosed postal. Samples inclosed.—CAMBRIDGE BOTANICAL SUPPLY CO., *Cambridge, Mass.*"

EDITORIAL.

Our readers will see by reference to a preceding page that one of the recommendations of the Committee on Bibliography which was approved by the Madison Botanical Congress is to be carried into effect at once. This is the publication of an author-catalogue of botanical papers relating to American botany. It has been of great advantage to botanists to have for reference the useful index to literature relating to American botany, which has been for several years a feature of the *Bulletin* of the Torrey Botanical Club. (We might take this opportunity, by the way, to express our pleasure that the doubts we possessed as to the permanence of this department at its inception have proved to be entirely unfounded.) This index is now to be made as complete as the co-operation of a number of specialists can make make it. What is of equal, if not of greater, importance is that the type already set up for this monthly index is to be used in printing the entries on index cards, and these cards are put on the market therefore at a cost far below what it would be if the matter had to be collated and printed separately.

In the production of this highly desirable result several factors have co-operated. In the first place, the editor who directs, and the members of the Torrey Botanical Club who support the *Bulletin* ought to receive the thanks of botanists. In the second place, even this first step would probably not have been taken had it not been for the Botanical Congress which briefly discussed the matter of bibliography last summer. For this Congress gave opportunity for the expression of approval which encouraged the editor of the *Bulletin* to preserve a department which he was tempted to abandon on account of the immense amount of work it entailed and the desirable space it occupied. It also gave occasion for the appointment of a committee on bibliography, in conference with whom Dr. Britton agreed to the typographical changes which have made the issuance of these cards possible. And finally, it is through the efforts of a member of this committee that the distribution and sale of the cards has been arranged with the Cambridge Botanical Supply Co.

The Gazette desires in every way to promote the success of this first venture which is the earnest, we trust, of yet more abundant harvests to be reaped through the cordial co-operation of generous-souled workers.

***

The writer in *Zoe*, "K. B.," who writes sneeringly of the botanical gatherings of the past summer appears sadly out of harmony with the spirit of the times among the botanists. Her envenomed pen stabs

chiefly at one, it is true. A more unscientific and unlovely spectacle it would be hard to find, than this disparagement of fifty or sixty other botanists because they choose to honor, however slightly, one whom she dislikes. Such bitter personalities only awaken compassion and stir regret; they are now-a-days unworthy of rejoinder.

CURRENT LITERATURE.

A Cuban text-book on botany.

An interesting phase of development of botanical teaching on this side of the Atlantic, is denoted by the recently issued text "Elementos de Botánica" part 1, by Dr. Juan Vilaró Diaz, of the University of Havana.

In a lengthy preface, Dr. de la Maza states that the work is called out by the want of a text in Spanish, and by the fact that foreign texts use, for illustration of plant phenomena, forms with which the Cuban student can not become familiar, and are otherwise unsuitable to accompany the courses of lectures in natural history offered in that University. Quite naturally he holds that the student can derive more practical advantage and general instruction from a study of the "forms that live in the beautiful climate of the magnificent Antilles."

The author divides the subject into static and dynamic botany. The volume just issued is concerned with the first, which it considers under the heads of cellulography, anatomy, morphology, embryology.

The relationship of the cell constituents is clearly outlined, and the author extends the text to include brief discussion of phases of the behavior and products of protoplasm, which do not usually find a place in elementary works. As an instance, under colors are paragraphs on pigments, origin and biological significance of colors, illumination, etiolation, protective colors, preventive colors, sexual colors typical colors, and attractive colors.

Throughout the entire work, forms and their relations are correlated with the more general functions of the organs in a manner that is very attractive. The economic relations of the plant are everywhere touched upon, and the author makes quite an excursion into the "tropisms," movements and carnivorous action. Under the latter head a cut and some interesting matter on the carnivorous action of Pinguicula, is taken from the U. S. Fish Commission report for 1885.

It could not be expected that the author of a pioneer text in such a musical language, would deny himself the privilege of introducing some new terms into our hazy terminology. He has, however, but

sparingly availed himself of the privilege so far, a self-denial it is hoped he will be able to sustain in the second part now in preparation, on physiology. In the present volume he introduces three terms coined by Dr. de la Maza, viz., *embriobroma*, the albumen of the seed, *embriobroma nucleogénito*, the perisperm of Schleiden, *embriobroma saccagénito*, the endosperm of Schleiden.

The breadth of thought, arrangement of matter, free compilation and simple direct style of the writer go to make up a text, that can but awaken enthusiasm among the students for whom it is intended. In conjunction with the high grade of teaching which the author represents, it will carry such inspiration, that we may hope soon to see a group of earnest workers at the University of Havana, who amid the rich flora of this tropical region, may accomplish much, especially in the domain of plant ecology.

The text is largely adapted after van Tieghem, the illustrations are from drawings by the author, Sachs, Reinke, and others. The publishers have done scant justice in this matter, while the usefulness of the book is materially lessened by the absence of a table of contents. It is but proper to say, however, that the book has some features that could be introduced into American texts to their distinct improvement.—D. T. MacDougal.

Recreations in botany.

Our readers will bear us witness that we have cordially welcomed every attempt to restate the more recondite matters of botany in such fashion as to render them more easily understood and more interesting to those who were not botanists. If we have occasion to criticise severely some attempts in this direction, it is because they are made without the scientific knowledge and literary ability which are the precedent conditions to successful popularizing of botany. We again express the hope that some of our well-trained botanists will devote a little of their time and energy to the popular exposition of the science. They owe this to their day and generation. The book before us is an attempt to do a desirable thing, for which the author deserves praise, but it is to be regretted that she was so poorly equipped for the task. The text of these "recreations in botany"[1] appeared first as a series of articles in *Harper's Bazar*. It is a pity that some good friend of the writer did not advise her to let them die with that ephemeral life, rather than permit rejuvenescence in the form of a book. More or less pertinent illustrations have been gathered from the storage vaults

[1] Creevey, Caroline A.—Recreations in botany. Small 8vo. pp. xiv+216. figs. 61. New York: Harper & Bros. 1893.

of the Messrs. Harper, and some decidedly original ones added by the author. The latter, and some of the others are crude, ill-drawn, and even grotesque caricatures of what is intended, made all the worse looking by comparison with the graceful and artistic work of Hamilton Gibson and Alfred Parsons.

The writer is evidently a lover of flowers and familiar with many of the flowering plants of the Atlantic region. In chapters relating to these she is at her best; but when she turns to physiology or to the lower plants, she writes a sorry mixture of fact and fancy. Even her facts seem to have been put into a kneading machine and thoroughly incorporated; and they are fed out often without the least reference to their relations.

Some of the opening sentences of the book are calculated to give a botanist cold shudders. Witness: "The pursuit of botany ought to be ranked as an outdoor sport." "For (and this is one of the points I wish to emphasize) botany is the easiest of all the sciences and can be engaged in without a teacher." Which she has too evidently done.

The chapter on plant movements furnishes some queer information: "The boat-shaped desmids and diatoms jerk themselves over considerable distances. The cilia (hair-like processes) of some mosses move about in water. Oscillaria are curious one-celled plants, which, under the microscope, look and wriggle like angle-worms." But it is when the cryptogams are reached that the author flounders most hopelessly. These plants, she says, "possess this advantage over our garden plants, that many of them can be studied in winter." "In such plants the sap does not circulate, but water passes freely though the cell walls." "Azolla looks like a creeping moss or liverwort." "Being small, many of them invisible to the naked eye, they [mosses] do not need a fibrous skeleton." In the scale-mosses "mixed with the spores are elaters, called macrospores." "The scale-mosses under a microscope look like lizards or curiously shaped reptiles." Speaking of the lichens she says, "the gonidia, a layer of green cells in the thallus, under a transparent cover called the hypha, divide each one into two, and form new plants. They are parasitic upon the lower layer of the thallus."

The algæ seem to be if possible less understood by the author than other groups. Speaking of algæ in general, "the spores," she says, "have a tendency to divide into four parts and are called tetraspores. They are provided with cilia either in pairs or all around their ball-shaped bodies. . . . Each cell seems capable of propagating two new plants by division. Another remarkable means of propagation is by 'conjugation'." "Many algæ are edible. The dulse of the Scotch

and the tangle of the Swede are made from algæ." "Zygnemas are composed of long tubes joined together by short ones, all marked with beautiful spirals or crosses, or other regular figures. They are large confervæ, and are found in great numbers fifteen thousand feet up the Himalayas, in the cold springs which rise from the glaciers." "The famous red-snow . . . is a cell containing starch and nitrogen; in other words protoplasm. . . . An allied alga is the *Palmella* (sic) *cruenta*, deep red in color, found on stale bread and meat, or upon musty walls of houses."

We cannot forbear one further quotation, since these are more for the delectation of our readers than as a justification of our criticism. "The ferment-mould inhabits liquids—wines, ciders, vinegars, and the like. The story is told of a man who placed his cask of wine in the cellar to age. Some time afterwards, when he attempted to open the cellar-door, it was blocked by great growths of fungus. The cellar was literally filled with the fungus, which had reveled in the wine leaking from the cask. The empty cask was lifted on top of the fungoid growth to the ceiling. This is the famous fungus found in the London docks, swinging and waving like gigantic cobwebs."

Miss (or is it Mrs.?) Creevey declares, at the end of her book, that "the object of the foregoing chapters has been, not a scientific treatise on botany, but to show how comparatively simple and easy it is, and what a pleasure it is, to know something—a great deal—about plants." This naiveté recalls the apt rebuke of an American humorist, "It's better not to kno so menny things than to kno so menny things that ain't so."

It would have been better for the author (and for the world) if she had not been so impressed with the idea that "it is as a recreation, a summer amusement, that the pursuit of botany is earnestly recommended." We recommend her to suppress this book and to give her undivided attention to botany for a series of years before she again ventures to popularize it.

It is not so remarkable that ignorance and confusion of ideas should exist; it is amazing that they should so frequently get into type. We are surprised that the Messrs. Harper would allow such a publication to bear their imprint.

OPEN LETTERS.

The botanic annual.

In the October issue of the GAZETTE Mr. W. T. Swingle presents a number of remarks on the idea of having an annual report on American botanical literature. The outcome of Mr. Swingle's consideration

is that *no* such publication should be made. As I was one who declared himself willing to work, when the GAZETTE had said a great deal about the desirability of a work this kind, I shall try to show that it is not for my personal pleasure that I did so. When I *was asked* to present my idea in the GAZETTE, and, afterwards, in Madison brought up the matter again, I thought that the GAZETTE had laid the foundation, viz., showed reasons for publishing an annual or yearly list of botanical publications. From the the last article which causes these lines to appear, I understand that Mr. Swingle wishes either no annual at all, or one published in German or French.

The *Botanischer Jahresbericht* cannot be relieved from the charge of neglect. A work of this kind, one of the most expensive periodicals ever seen in our line of work, ought to rely upon the books and papers which could be bought or otherwise promptly secured, and not only upon donations. It should obtain everything published, so that a "nicht gesehen" never could be alleged. If the writer undertook to compile all the literature on vegetable physiology—as, in fact, he has—he would be badly off if he indexed only such papers as he could conveniently lay his hands on, and presented that as the literature "aller Länder." But it must be admitted that it is extremely difficult to get hold of even the titles.

What we need, are *complete* bibliographies in our science, and this first of all. It is quite true that American publications are difficult to obtain in Europe, and here, of course, the booksellers have the responsibility, either in the way of not having the means of procuring the books, or putting too high prices on them if they have them.

I always thought that German, English, and French were the three main languages of the globe. Mr. Swingle, himself, thinks that if a botanist can not read all of these, he "ought to give up his business." Therefore, every botanist ought to be able to read the annual in English. From this to Japanese is a large gulf; nobody would publish such an annual in Japanese, unless joking. But if it were to be published in German, how many English students would be able to read it then? Not many. French would give a worse result.

Two publishers are still willing to take the annual. I repeat this, since it was not believed, as a *fact*. Such annuals as the one proposed are generally well received, when complete. The *Repertorium annuum botan. period.* by Bohnensieg and Burck, if it had had good backing, would have been more useful than the *Jahresbericht* is; it contained complete lists of references, while Just's (or rather his successors') work is in many regards incomplete. It would not matter if ten different annuals in the three most important languages of the world were published, if those ten volumes gave *complete* lists of literature and *objective reviews*. Botanists who wish to see, year by year, what appears in the literature on the subject of their specialty, would more gladly go through these ten volumes and find everything, than they would consult the *Jahresbericht* alone and find a part of it.

I have great regard for Mr. Swingle's objections, therefore I tried to meet all of them. The GAZETTE deemed the subject an important one, therefore I hope to be pardoned for discussing it at length.—J. CHRISTIAN BAY, *Bacteriologist of the Iowa State Board of Health, Ames, Iowa.*

NOTES AND NEWS.

DR. OSKAR LOEW of the University of Munich has been called to the University of Tokio as professor of agricultural chemistry.

REV. C. F. MAXWELL, of Dublin, Texas, is engaged on drawings of the oaks of western Texas which he expects to publish next summer after the style of Kellogg's West American Oaks.

THE PAPERS AND DISCUSSIONS before the Society for the Promotion of Agricultural Science at its Madison meeting occupy the larger part of the Aug.–Sept. number of Agricultural Science.

DR. GEORG DRAGENDORFF, author of the well known work on "Plant Analysis," and professor of pharmacy in the University of Dorpat, Russia, has resigned his position and removed to Bern, Switzerland.

PROF. DR. P. SORAUER resigned, October first, the directorship of the Experiment Station for Vegetable Physiology at Proskau, Germany, and Dr. Rudolf Aderhold of Geisenheim has been appointed his successor.

DR. GEO. E. STONE, who has been studying abroad, especially in Prof. Pfeffer's laboratory at Leipzig, has been appointed assistant professsor of botany in the Massachusetts Agricultural College at Amherst. He will give particular attention to physiological botany.

THE OBJECT AND METHODS of seed investigation and the establishment of seed control stations are carefully and ably treated by Dr. Oscar Burchard of Hamburg, Germany, in the *Experiment Station Record* (IV, 793–801, 882–900). The article contains very full information, and is well illustrated.

THE SIXTH ANNUAL REPORT (1892–3) of the Scientific Station for Brewing in Chicago, shows a remarkably large amount of work accomplished. In the bacteriological department, in charge of Mr. A. Lasché, examination was made of 1059 samples of yeast, 1105 of beer, and 280 of water. The results are instructive to others beside those engaged in the brewing industry.

IN A RECENT NUMBER of *Studies from the biological laboratory* of Johns Hopkins University (vol. v, Oct. 1893) Dr. J. P. Lotsy presents some facts regarding the structure of cypress knees, claiming to have found fungous spores present and occasional mycelium, and Mr. B. W. Barton describes and illustrates the origin and development of the stichidia and tetrasporangia in Dasya elegans.

THE FOLLOWING NEW BOOKS have been announced for early publication: "Handbook of systematic botany," by E. Warming, translated from the Swedish by M. C. Potter, from the press of Swan Sonnenschein & Co.; "Practical physiology of plants," by F. Darwin and E. H. Acton, from the Cambridge University press; "A student's textbook on botany," by Sidney H. Vines, copiously illustrated.

IN THE ANNUAL report of the Vermont Experiment Station for 1892 is some interesting matter upon plant diseases, especially of the potato, oats, apple, cucumber and lettuce, by L. R. Jones. In the simi-

lar report of the Wisconsin Station for 1892 is an illustrated article by F. H. King on the natural distribution of roots in field soils, containing important additions to our knowledge of the rooting habits of plants, and articles by E. S. Goff upon use of fungicides, and the deterioration of the natural vigor of strawberry plants through the continued action of spot disease (Ramularia Tulasnei). The latter points out a danger to the successful growing of crops that has not yet been sufficiently well recognized.

AMONG RECENT station bulletins are the following having botanical interest: "Colorado weeds," by C. S. Crandall (Colo. no. 23). Beside some general observations nine kinds of weeds are described and figured; three of the kinds are illustrated both from pen sketches and photographs, and it is very noticeable that the former method is adapted to show more detail of structure, and the latter to better present the habit of the plant. "Loco and larkspur," by David O'Brine (Colo. no. 25), is an interesting subject, which receives preliminary treatment from the chemist's and physiologist's standpoint, with the tentative conclusion that those species of Astragalus and related plants called loco weeds are not responsible for the loco disease. L. H. Pammel and F. C. Stewart (Iowa no. 21), write, the former upon bacteria connected with the dairy, and the latter upon the impurities of clover seed.

MR. HENRY L. CLARKE, of the University of Chicago, in the *American Naturalist* for September, publishes a paper on "The philosophy of flower seasons", which suggests a very interesting field of research. The field is suggested in somewhat shadowy outline, and the illustrations used are meant to be of the most general kind. After passing in review the large groups as represented in the "Manual range", and pointing out their season of blooming, the general deduction is made that "from early spring to late autumn there is a progression in the general character of the flower-groups, from the lower to the higher, successive groups succeeding each other in time, parallel groups coming synchronously." Various modifying conditions are mentioned, such as the necessities of pollination.

THE DATES of publication of the parts of Torrey & Gray's "Flora of North America" and Hooker & Arnott's "Botany of Beechey's Voyage" have been published by Mr. B. Daydon Jackson in *Journal of Botany* (October) as follows: *Flora of North America*, Vol. I, Part 1 (pp 1–184), July, 1838; Part 2 (pp. 185–360), October, 1838; Part 3 (pp. 361–544), June, 1840; Part 4 (pp. 545–698), and Errata, June, 1840: *Botany of Beechey's Voyage*, Part 1 (pp. 1–48), 1830; Parts 2 and 3 (pp. 49–144), 1832; Part 4 (pp. 145–192), 1833; Part 5 (pp. 193–240), 1836; Part 6 (pp. 241–288), no indication of date; Parts 7 and 8 (pp. 289–384), 1840; Parts 9 and 10 (pp. 385–486), 1841. In the case of the *Botany Beechey* the dates are obtained from those of the new genera as given in Pfeiffer's *Nomenclator;* and hence the date of Part 6, containing no new genera, is left with no clue.

GENERAL INDEX.

***The more important classified entries will be found under the following heads: *Diseases*, *Floras*, *Journals*, *Personals*, *Reviews*.

*** Names of synonyms are printed in *Italics;* names of new species in **bold face;** * signifies death.

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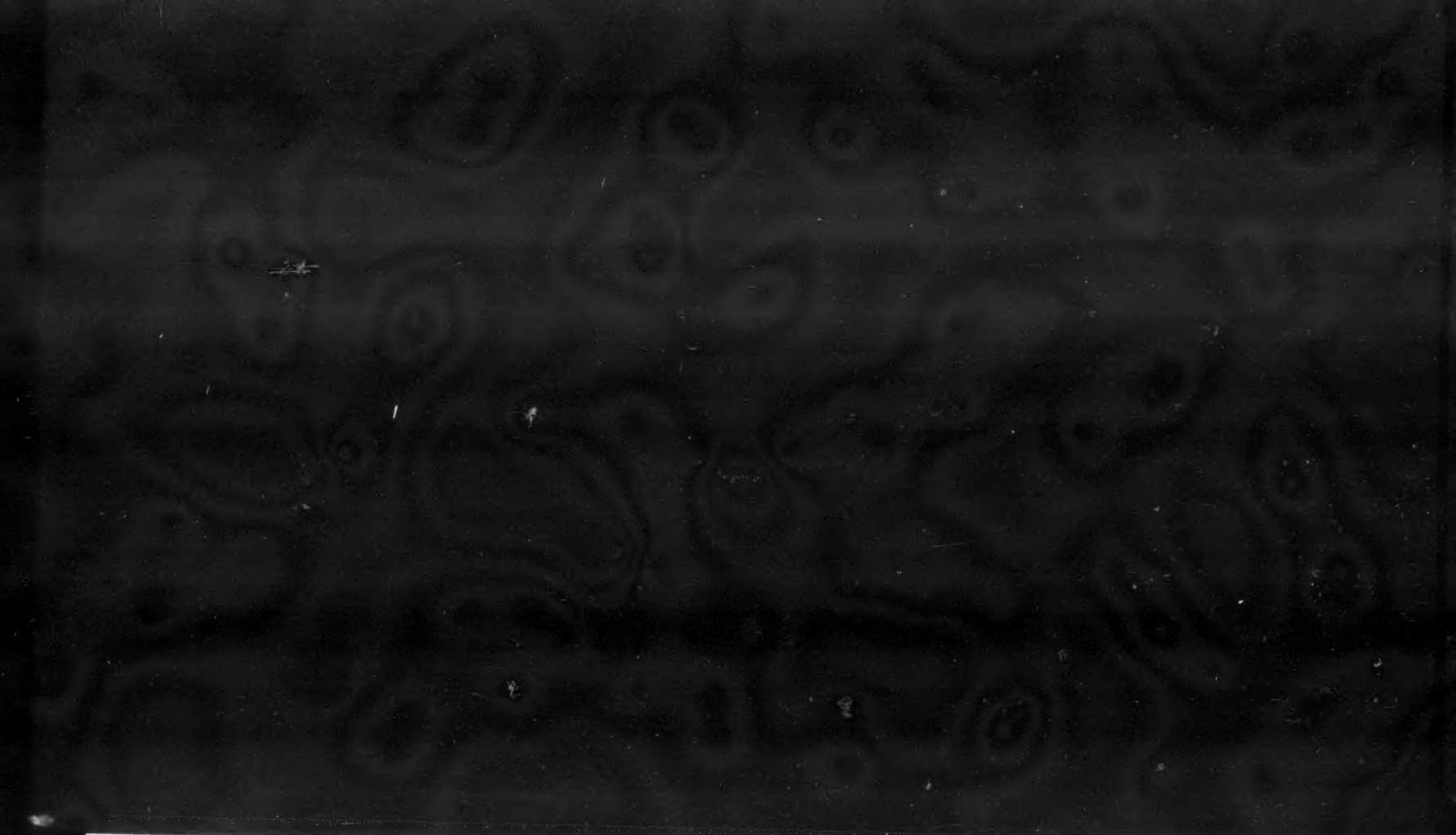
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